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Research article

Effects of Different Manures on the Growth Performance of Pechay (*Brassica rapa* L.) Under Visayas State University Condition

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Abstract: The sudden rise in the demand for food in global markets has led farmers to adopt sustainable agricultural practices to reduce the negative impacts of synthetic fertilizers on soil, water, and ecosystems. This study assessed the effectiveness of vermicast, cattle manure, and goat manure and their combinations on the growth performance, nutrient content, and heavy metal accumulation in peachy. The study used a Completely Randomized Design (CRD) with six treatments and three replicates each and collected the data on plant height, number of leaves, leaf area, chlorophyll content, root biomass, and fresh and dry weight. Proximate tissue analysis was done to determine the NPK content and accumulated heavy metals. Data were analyzed using ANOVA in CRD, and a post-hoc analysis using Tukey's HSD test was conducted after significance was found. The results indicated significant differences ($P<0.05$) in several growth parameters like plant height with cattle manure, number of leaves with vermicast, leaf area with vermicast, and chlorophyll content with mixed manures. Significant differences ($P<0.05$) were also found in fresh weight with vermicast and root biomass with mixed manures. These treatments improved soil nutrient profiles post-harvest, although there were reductions in available phosphorus and exchangeable potassium. The findings highlight the potential of organic fertilizers to enhance pechay growth performance, supporting sustainable agricultural practices that align with the Sustainable Development Goals (SDGs). Further research on organic fertilizer applications and their long-term effects on soil health and crop nutrition is recommended.

Keywords: Growth performance; organic fertilizers; potting media; sustainable agriculture; synthetic fertilizer

1. Introduction

The growing demand for food in world markets leads farmers to adopt various strategies in agriculture to enhance their production [1]. While chemical fertilizers have traditionally been seen as the most effective way to increase crop yields worldwide, their negative impact on soil, water, and ecosystems limits their long-term use in farming practices, and the types and levels of fertilizers utilized in crop production are crucial factors that significantly impact cropping systems [2]. Farmers employ alternative and

economical techniques to make food production more sustainable, including crop rotation, biological pest management, composts, and organic fertilizers, which help mitigate the adverse environmental effects [3]. Currently, there has been a noticeable shift towards reducing the reliance on synthetic fertilizers, particularly those applied to the soil, such as nitrogen (N), phosphorus (P), and potassium (K), resulting in a significant decrease in their usage. Additionally, health-conscious consumers' rising preference for organically grown agricultural products has increased interest in foliar fertilization and the adoption of organic fertilizers as viable alternatives to fulfill plant nutrient requirements throughout the growing season [4].

Pechay (*Brassica rapa* L.) is one of the most cultivated leafy vegetables across the globe due to its short time production (35 days after transplanting) and contributes substantially to vegetable production in Asia, Europe, and North America [5]. Pechay has consistently grown in the Philippines, becoming an essential component of the country's vegetable output at approximately 47,000 metric tons in 2022, based on the Philippine Statistics Authority data [6]. Although plants only require small amounts of nutrients, their growth can be improved by soluble mineral nutrients from soil amendments like manure. This has been supported by studies conducted by Waniyo et al. [7] and Han et al. [8] Additionally, using organic fertilizers has been found to enhance vegetable yield, per the study by Li et al. [9] As highlighted in the study, these amendments improve yield and nutritional quality and significantly affect the soil microbiome due to compost's beneficial impacts [10]. However, more scientific research needs to be discovered on the effects of locally available ameliorants on pechay production in Leyte. This is primarily because, based on the study of Gonzaga et al. [11] Pechay is traditionally cultivated in open fields using conventional farming methods that involve synthetic fertilizers and pesticides. Therefore, this study aimed to investigate the effects of four different animal manures on the growth performance of pechay under the conditions at Visayas State University. Specifically, it assessed the growth performance of Pechay treated with four different animal manures. It analyzed the levels of nitrogen (N), phosphorus (P), and potassium (K), as well as heavy metals like lead (Pb) and cadmium (Cd) in the Pechay tissues. This research has made significant contributions to sustainable agriculture that align with global and national initiatives toward a more responsible and ecologically sound future. The results of this study help achieve the Sustainable Development Goals [12], more importantly, Goal 2 (Zero Hunger), Goal 12 (Responsible Consumption and Production), and Goal 15 (Life on Land). By exploring the effect of soil potting media on the growth characteristics of Pechay, we are actively engaging in practices that promote food security, responsible resource consumption, and the preservation of land ecosystems. The study addresses the pressing need for sustainable agricultural practices to enhance crop nutrition, increase food production, improve soil health, and enhance microbial activity.

2. Methodology

2.1 Location

This study was conducted to determine and assess the effects of various animal manures on Pechay's growth characteristics. It was conducted at the Department of Agronomy laboratory of Visayas State University in Baybay City, Leyte, Philippines, located at coordinates 10°44'54.1 N 124°47'33.9 E. The study offers insights into growth performance and heavy metals associated with applying different organic fertilizers- vermicast, cattle manure, and goat manure- alongside inorganic fertilizers.

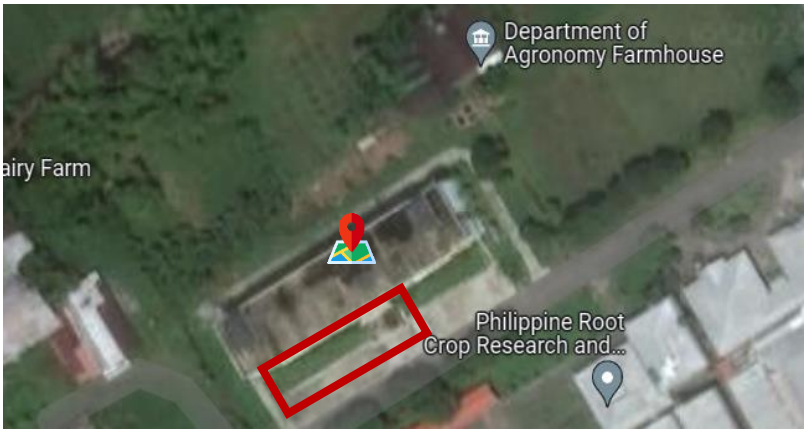

Figure 1. Location of the study within Visayas State University

2.2 Inputs, Treatment Preparations and Application

Farm supplies such as 5 inches by 5 inches polyethylene pots, pechay seeds, urea (46-0-0), and complete fertilizer (14-14-14) were acquired from Agrivet or other reputable agricultural input suppliers in Baybay City, Leyte. Pechay, which has an 85% germination rate and 99% purity, was used in the study. Vermicast was purchased from reliable vermi raisers within Baybay City, Leyte. Cattle and sheep manure was sourced from the Department of Animal Science of the Visayas State University. The nutrient content of each soil amendment, including nitrogen (N), which is determined by the Kjeldahl method; phosphorus (P), which is determined by the molybdenum antimony colorimetric method; and potassium (K), which is determined by flame photometry, was analyzed to determine the nutrient components of the soil. The gathered soil ameliorants were added and mixed with the soil collected from the field laboratory area of the Department of Agronomy, Visayas State University. A total of three (3) kilograms of soil and the computed amount of organic fertilizer (0.86 kg of vermicast, 0.71kg of cattle manure, 0.771 kg of sheep manure, and 0.78kg of mixed manures) were placed per 5 inches by 5 inches polyethylene pots. The application of synthetic fertilizers will be based on the soil analysis results, considering the fertilizer recommendation of 135kg N, 90kg P, and 90kg K per hectare [13]. The application rate was based on the recommended rate to meet the specific nutrient requirements of the soil, promoting a balanced and efficient use of synthetic fertilizers.

2.3 Planting of Pechay

Seeds were sown in a seedling tray and kept in a nursery for ten days. After the seedlings have two to three true leaves, they are transplanted into polyethylene pots containing the prepared soil media. Cultural management practices like weeding, controlling insect pests, and managing water were employed whenever necessary until harvest.

2.4 Research Design

The study was arranged in a one-way, Completely Randomized Design (CRD). The study had six treatments, namely the Control (A), Synthetic Fertilizer (B), Vermicast (C), Cattle Manure (D), Sheep Manure (E), and a Mix of Vermi, Cattle, and Sheep Manure (F) with a ratio of 1:1:1. Each treatment was randomly assigned with three replicates. This design ensures an equitable distribution of treatments across all experimental units, mitigating potential biases and allowing for a comprehensive and unbiased evaluation of the influence of different animal manures on the nutritional profile of Pechay.

2.5 Data Collection

Growth Performance. Plant height measurements and number of leaves were gathered weekly until harvest, 35 days after transplanting. The leaf area index was measured using a digital leaf area meter. The chlorophyll content of the leaves and leaf temperature were analyzed using SPAD 502 Plus Chlorophyll Meter. Root biomass, fresh weight, and leaf-to-root ratio were also computed after the study.

Nutritional Content Analysis: Pechay samples were harvested at maturity (35 days after transplanting), and their nutritional content, including nitrogen, nitrogen (N), which is determined by the Kjeldahl method,

phosphorus (P) is determined by the molybdenum antimony colorimetric method, and potassium (K) that is determined by flame photometry, and the heavy metal contents – lead and cadmium using the atomic absorption spectrometry was analyzed in Central Analytical Soil Laboratory of Visayas State University.

Soil Analysis Post-Crop Removal. After harvesting, composite pooled samples of soil, organic and complete fertilizers from bulk mixes of each treatment were then collected and brought to the Central Analytical Soil Laboratory of Visayas State University for chemical analyses for the nitrogen (N), phosphorus (P), and potassium (K).

2.6 Statistical Analysis

The data was analyzed using the analysis of variance (ANOVA) in CRD to evaluate significant differences among treatments. The data was processed using STAR software. A post hoc Test using Tukey's Honestly Significant Difference (Tukey's HSD) test was performed to determine significant differences among treatment means.

3. Results and Discussion

3.1 Organic amendment properties before the conduct of the study

Table 1 presents the nutrient content of the organic amendments used in the study before they were applied to the soil. The amendments analyzed include sheep manure, vermicast, cattle manure, and a mix of these materials. The nutrients measured were nitrogen (N), phosphorus (P), and potassium (K), expressed as a percentage of the total composition.

Table 1. Organic amendment properties before the conduct of the study
Source: Central Analytical Laboratory of Visayas State University

Organic Amendments	Measured Values		
	Total N (%)	Total P (%)	Total K (%)
Sheep Manure	1.514	368.36	113.65
Vermicast	1.723	366.59	117.36
Cattle Manure	1.695	335.43	118.38
Mix	1.630	367.54	115.28

3.2 Soil properties with organic amendments after harvesting

Table 2 shows the soil nutrient content after applying the different organic amendments. The same nutrients—nitrogen (N), phosphorus (P), and potassium (K)—were measured to assess how the amendments impacted the soil properties throughout the study.

Table 2. Soil properties with organic amendments after the conduct of the study
Source: Central Analytical Laboratory of Visayas State University

Treatments	Measured Values		
	Total N (%)	Total P (%)	Total K (%)
Soil with Sheep Manure	0.211	368.36	113.65
Soil with Vermicast	0.242	366.59	117.36
Soil with Cattle Manure	0.167	335.43	118.38
Soil with Mix	0.208	367.54	115.28

3.3 Average plant height

The average plant height showed a significant difference ($p=0.0101$) during the second to fourth week after transplanting, while no significant differences ($P>0.05$) were observed during the first week after

transplanting. As presented in Table 3, data showed that plant heights of Pechay were highest on pots fertilized with cattle manure and mixed manures at 17.80 cm and 17.5 cm, respectively. However, the plant height of both organic fertilizers was statistically comparable with vermicast, sheep manure, and synthetic fertilizer at 15.37 cm. 13.93 cm, and 13.5 cm, respectively.

Table 3. The weekly average plant height (cm) of Pechay is affected by the different potting mediums.

Treatment	Weeks				
	Initial	**1st**	**2nd**	**3rd**	**4th**
Control	9.17	9.80	11.23 b	12.23 a	12.73 b
Vermicast	8.87	8.97	12.77 b	14.03 a	15.47 ab
Cattle manure	9.97	9.80	16.10 a	16.80 a	17.80 a
Sheep manure	9.53	10.37	12.73 b	13.33 a	13.93 ab
Synthetic fertilizer	8.50	9.17	12.77 b	13.13 a	13.50 ab
Mix manures	7.80	8.83	16.30 a	16.90 a	17.50 a
Mean	8.64	9.49	13.65	14.41	15.16
CV (%)	10.64	11.70	14.17	12.39	10.83
p-value	0.2244	0.5335	0.0379	0.0298	0.0101

This means that columns with different letters are significantly different at a 5% significance level in Tukeys's Honest Significant Difference (HSD) Test.

In contrast, the lowest plant height was recorded on Pechay planted on soils without ameliorants at 12.73 cm. Furthermore, the height of peachy in vermicast, sheep manure, and synthetic fertilizer is also statistically comparable with that of the control treatment. A similar result was observed in Pechay, where plant height is highest on organic fertilizers such as vermicompost [14].

3.3 Average number of leaves

Table 4 presented the effect of treatments on the number of pechay leaves on weeks 1, 2, 3, and 4 after transplanting. Data showed that treatment means on the number of leaves at weeks 2, 3, and 4 are significantly different and are influenced by the different potting mediums at $\alpha 0.05$.

Table 4. The different potting mediums affect the weekly average number of Pechay leaves.

Treatment	Weeks				
	Initial	**1st**	**2nd**	**3rd**	**4th**
Control	2.00	3.00	4.00 b	5.33 bc	6.33 bc
Vermicast	2.00	3.67	4.33 b	8.67 a	10.33 a
Cattle manure	2.33	4.00	7.00 a	8.00 ab	9.33 ab
Sheep manure	2.00	3.00	4.67 ab	5.00 c	5.00 c
Synthetic fertilizer	2.00	2.67	4.00 b	5.33 bc	6.00 bc
Mix manures	2.33	4.00	7.00 a	8.00 ab	9.67 ab
Mean	2.11	3.39	5.17	6.72	7.78
CV (%)	15.79	19.67	17.07	16.07	18.43
p-value	0.5705	0.1190	0.0016	0.00026	0.0022

This means that the columns with the different letters are significantly different from each other at a 5% level of significance in Tukeys's Honest Significant Difference (HSD) Test.

The number of leaves was shown to increase significantly two weeks after transplanting, and this was observed in pots where cattle manure and mixed manure were applied; however, statistically, it is comparable with sheep manure. Three (3) weeks and the fourth week after transplanting, the most significant number of leaves was recorded in the Pechay on vermicast, statistically comparable with cattle manure and mixed manures. Throughout weeks 2, 3, and 4 after transplanting, the least number of leaves was observed on the control treatment where soil ameliorants were added with a mean value of 4, 5.33, and 6.33 leaves, respectively, but is statistically comparable with those Pechay applied with synthetic fertilizer and sheep manure.

The results are consistent with those of Kaur[15], who found that organic waste processed by naturally occurring earthworms produces vermicast. This vermicast supplies nutrients and other soil stimulants, enhancing soil quality and boosting vegetable and ornamental crops' growth, flowering, and yields.

3.4 Plant weight, root biomass, and leaf-to-shoot ratio

Dry biomass for both the shoot and the root significantly differed for pechay at α0.05 grown under different potting media. Table 5 shows that the vermicast had the highest fresh weight (29.50 grams) but is statistically comparable with mixed manure (27.50 grams) and cattle manure (27.17 grams). Though statistically different, sheep manure, synthetic fertilizer, and control had lower fresh weights of 16.67 grams, 16.08 grams, and 12.92 grams, respectively.

Table 5. Plant weight, Root biomass, and leaf-to-shoot ratio of Pechay as affected by different potting mediums.

Treatment	Whole Plant (g)	Shoot biomass (g)	Root Biomass (g)	Shoot to Root Ratio
Control	12.92 ^{b}	4.33	0.50 ^{b}	8.86 ^{a}
Vermicast	29.50 ^{a}	11.33	1.18 ^{ab}	8.70 ^{a}
Cattle manure	27.17 ^{a}	14.00	1.85 ^{ab}	7.46 ^{ab}
Sheep manure	16.67 ^{b}	3.67	0.81 ^{ab}	4.06 ^{c}
Synthetic fertilizer	16.08 ^{b}	4.33	1.26 ^{ab}	3.74 ^{c}
Mix manures	27.50 ^{a}	15.33	2.63 ^{a}	5.66 ^{bc}
Mean	2.11	8.83	5.17	6.72
CV (%)	15.79	47.28	17.07	16.07
p-value	0.0000	0.0000	0.0345	0.0001

This means columns with the same letters are not significantly different from each other at a 5% significance level in Tukeys's Honest Significant Difference (HSD) Test.

Differences in treatment means of root biomass showed significant differences as mixed manure has the highest root biomass with 2.63 grams/pot and is statistically comparable with organic and inorganic fertilizers. Cattle manure weighed 1.85 grams/pot, synthetic fertilizer weighed 1.26 grams/pot, and vermicast weighed 1.18 grams/pot. On the other hand, the control treatment has the significantly lowest root biomass, weighing 0.50 grams/pot.

In leaf to root ratio, differences in treatment means showed significant differences at α0.05. Control has the highest leaf-to-root ratio, with 8.86, statistically comparable to vermicast (8.70) and cattle manure (7.46). In contrast, the leaf-to-shoot ratio of cattle manure was comparable to that of mixed manures. [16] found that pechay applied with organic fertilizer had higher dry matter weights of its shoots and roots compared to no fertilizer and inorganic fertilizer. Similarly, [17] found that applying organic fertilizer to lettuce significantly increased the dry weight of leaves and roots compared to the control with 0% compost.

3.6 Leaf Area, Chlorophyll, and Leaf Temperature

Table 6 indicates that the leaf area (cm^2) of plants in vermicast has the highest leaf area of 90.12 cm^2, which is statistically comparable with mixed manure (80.34 cm^2) and cattle manure (78.02 cm^2). These treatments showed to be significantly different compared to treatments with sheep manure, synthetic fertilizer, and control. Mrabet et al. [17] observed similar results, noting that lettuce treated with vermicompost produced significantly broader leaves compared to the control group ($p < 0.05$). Since photosynthesis is a crucial physiological process responsible for most dry matter production in crop plants, the presence of different photosynthetic pigments, such as chlorophyll, can measure it. In the mean differences of the chlorophyll content, significant differences were observed among treatment means at α0.05. The highest chlorophyll content was recorded on Pechay on mixed manures with 55.79 SPAD, which is statistically comparable with vermicast, 47.63 SPAD, cattle manure, 44.18 SPAD, and sheep manure, 40.92 SPAD. It is, however, significantly different on Pechay planted on pots applied with synthetic fertilizer at 29.54 SPAD, control treatment with 33.15 SPAD, and also with that of the vermicast, cattle manure, and sheep manure.

The treatment means on temperature showed no significant difference based on statistical analysis at α0.05, where the temperature consistently ranges from 25.19 °C to 28.81°C.

Table 6. Average leaf area index, chlorophyll, and leaf temperature of Pechay as affected by different potting media

Treatment	Leaf Area (cm^2)	Chlorophyll (SPAD)	Temperature (°C)
Control	28.51 ^{b}	33.15 ^{b}	28.81
Vermicast	90.12 ^{a}	47.63 ^{ab}	27.78
Cattle manure	78.02 ^{a}	44.18 ^{ab}	25.19
Sheep manure	36.88 ^{b}	40.92 ^{ab}	28.79
Synthetic fertilizer	34.76 ^{b}	29.54 ^{b}	28.61
Mix manures	80.34 ^{a}	55.79 ^{a}	28.61
Mean	58.10	41.87	27.96
CV (%)	19.94	18.96	8.56
p-value	0.0000	0.0167	0.4362

This means columns with the same letters are not significantly different from each other at a 5% significance level in Tukey's Honest Significant Difference (HSD) Test.

3.7 Tissue Analysis of Pechay

The proximate analysis of Pechay tissues revealed significant variations in nutrient content and heavy metal accumulation across different potting media, as shown in Table 7. Based on statistical results, the gross energy content did not differ significantly among treatments (p=0.1272), with the mix manures treatment yielding the highest gross energy content (3312.33 cal/g) and vermicast the lowest (2863.33 cal/g). The lack of significant differences in gross energy content suggests that the choice of potting media is independent of the gross energy levels in Pechay. Regarding nitrogen content, although differences were observed (ranging from 2.38% in the control to 4.25% in the synthetic fertilizer treatment), these differences were not statistically significant (p=0.3971). The elevated nitrogen levels in the synthetic fertilizer treatment are expected, as synthetic fertilizers typically have higher nitrogen availability than organic amendments. However, the lack of significant differences across treatments could indicate that Pechay's nitrogen uptake efficiency is relatively stable across different potting media.

The phosphorus content, however, showed significant differences (p=0.0001) among treatments. The vermicast treatment exhibited the highest phosphorus content (0.2413%), significantly higher than the control and synthetic fertilizer treatments. This aligns with studies indicating that vermicast enhances phosphorus availability due to its high phosphatase enzyme activity, which increases phosphorus solubilization [18]. In

contrast, the synthetic fertilizer treatment had the lowest phosphorus content (0.2183%), possibly due to the fixation of phosphorus in less available forms. Potassium content also varied significantly across treatments ($p = 0.0161$). The cattle manure treatment resulted in the highest potassium content (3.06%), significantly higher than the synthetic fertilizer treatment, with the lowest potassium content (2.38%). Organic amendments like cattle manure enhance potassium availability through the slow release of nutrients, as Khaitov et al. [19] mentioned, which might explain the observed differences.

Table 7. Proximate analysis of Pechay tissues as affected by different potting media.

Treatment	Gross Energy (cal/g)	Total N (%)	Total P (%)	Total K (%)	Heavy Metals	
					Total Cd (ppm)	Total Pb (ppm)
Control	3297.67	2.38	0.2313^{b}	2.46^{ab}	<0.001	4.98^{b}
Vermicast	2863.33	2.86	0.2413^{a}	3.00^{ab}	<0.001	11.58^{a}
Cattle manure	2972.33	3.35	0.2307^{b}	3.06^{a}	<0.001	10.72^{a}
Sheep manure	3028.00	3.21	0.2357^{ab}	2.68^{ab}	<0.001	7.77^{ab}
Synthetic fertilizer	2974.33	4.25	0.2183^{c}	2.38^{c}	<0.001	5.05^{b}
Mix manures	3312.33	3.20	0.2350^{ab}	2.72^{ab}	<0.001	8.82 ^{ab}
Mean	**3074.67**	**3.21**	**0.2321**	**2.71**	**<0.001**	**8.15**
CV (%)	**7.14**	**31.63**	**1.50**	**8.34**		**24.02**
p-value	**0.1272**	**0.3971**	**0.0001**	**0.0161**		**0.0051**

This means columns with the same letters are not significantly different from each other at 5% significance level in Tukey's Honest Significant Difference (HSD) Test.

Heavy metal analysis revealed that cadmium (Cd) levels were below detection limits (<0.001 ppm) across all treatments, suggesting that none of the potting media contributed significantly to cadmium contamination. However, lead (Pb) content varied significantly ($p=0.0051$). It was higher than the set brassicas maximum limit (0.03 ppm) by the Codex Alimentarius [20], with the vermicast and cattle manure treatments showing the highest lead concentrations (11.58 ppm and 10.72 ppm, respectively), which were significantly higher than the control. These findings align with concerns raised in studies that organic amendments, particularly those of animal origin, can sometimes introduce heavy metals into the soil, as Rashid [21] noted, potentially leading to higher uptake by plants. However, the increased lead content of these vegetables can be reduced or removed by thoroughly washing the vegetables before removing the outer leaves before consumption or cooking.

3.8 Nutritional composition of soil before planting and soil nutritional properties of bulk mixes of each treatment after harvesting

Suleiman et al. [22] state that soil's physical and chemical properties determine the availability of nutrients to plants. For optimal crop production, it is essential to regularly monitor these properties to ensure long-term development and increased yields. Table 5 presents the soil properties before and after the study. Based on the results of the soil analysis, the total nitrogen after the study was increased to 0.101 % compared to 0.092 % before the study was conducted; however, in available phosphorus and exchangeable potassium, the results of the analysis were reduced to 85.83 mg/kg and 109.65 mg/kg compared to 250.10 mg/kg and 173.55 mg/kg respectively.

The analysis indicates that an increase in total nitrogen content could improve plant nutrient availability; a decrease in available phosphorus and exchangeable potassium could also affect plant growth and development and decrease soil fertility.

Table 8. Nutritional composition of soil before planting and soil nutritional properties of bulk mixes of each treatment after harvesting.

Properties	Measured values before the study	Measured values after the study
Total N (%)	0.092	0.101
Available P (mg/kg)	250.10	85.83
Exchangeable K (mg/kg)	173.55	109.65

Source: Central Analytical Soil Laboratory of Visayas State University

4. Conclusions

Based on the results, using vermicast, cattle manure, and mixed manures significantly improved the growth and yield performance of Pechay. This was evident in plant height, number of leaves, leaf area index, fresh weight, root biomass, shoot-to-root ratio, and chlorophyll content. Additionally, the study demonstrated that organic fertilizers greatly enhanced Pechay's growth and yield. Therefore, it is recommended to apply organic fertilizers, particularly vermicast, cattle manure, and mixed manure, as they positively influence growth and yield, especially regarding the number of leaves, leaf area, and fresh weight. Based on the results and conclusion of the study, the application of organic fertilizers such as vermicast, cattle manure, and mixed manure (vermicast, cattle, and Sheep) is recommended for Pechay cultivation due to their positive influence on growth and yield, particularly in terms of the number of leaves, leaf area, and fresh weight. However, thorough cleaning or removal of the outer leaves of the plants is recommended to decrease the lead content of the plants. For further improvement in this study, it is recommended that research be conducted on the use of other organic fertilizer sources and different amendment concentrations to achieve optimal harvest and post-harvest data. Additionally, further studies on Pechay production utilizing different methods of fertilizer applications, both organic and inorganic, should be pursued. Testing plant tissue for levels of antioxidants and other essential nutrients to assess and compare the nutritional value of plants treated with organic and inorganic fertilizers is also advised.

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References

[1] Staugaitis, G.; Viškelis, P.; Rimantas Venskutonis, P. Optimization of application of nitrogen fertilizers to increase the yield and improve the quality of Chinese cabbage heads. *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science* **2008**, *58*(2), 176-181. https://doi.org/10.1080/09064710701467118

[2] Adekiya, A.O.; Agbede, T.M. Effect of methods and time of poultry manure application on soil and leaf nutrient concentrations, growth and fruit yield of tomato (Lycopersicon esculentum Mill). *Journal of the Saudi Society of Agricultural Sciences* **2017**, *16*(4), 383-388. https://doi.org/10.1016/j.jssas.2016.01.006

[3] Siavoshi, M.; Nasiri, A.; Laware, S. Effect of organic fertilizer on growth and yield components in rice (Oryza sativa L.). *Journal of Agricultural Science* **2010**, *3*, 217-221. https://doi.org/10.5539/jas.v3n3p217

[4] Lian, H.; Ouyang, L.; Liu, J.; Yang, L.; Zou, P. Effects of different proportions of inorganic fertilizer and organic fertilizer on yield and quality of amaranth. Proceedings of the 2017 6th International Conference on Energy, Environment and Sustainable Development. *Advances in Engineering Research* **2017**, *129*, 911-915. https://doi.org/10.2991/iceesd-17.2017.166

[5] Shahbandeh, M. Vegetables production worldwide 2021, by type. Statista. **2023**. https://www.statista.com/statistics/264065/global-production-of-vegetables-by-type/

[6] Philippine Statistics Authority. Selected Statistics on Agriculture and Fisheries (SSAF). Gov.Ph. **2022**. Retrieved January 26, 2024, from https://psa.gov.ph/system/files/main-publication/%2528ons-cleared%2529_SSAF%25202022%2520as%2520of%252030082022_ONS-signed.pdf

[7] Waniyo, U.U.; Sauwa, M.M.; Ngala, A.L.; Abubakar, G.A.; Anelo, E.C. Influence of sources and rates of manure on yield and nutrient uptake of maize (Zea mays L.) in Maiduguri, Nigeria. *Nigerian Journal of Basic and Applied Science* **2013**, *21*(4), 259-265. http://dx.doi.org/10.4314/njbas.v21i4.3

[8] Han, S. H.; An, J.Y.; Hwang, J.; Kim, S.B.; Park, B.B. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (Liriodendron tulipifera L.) in a nursery system. *Forest Science and Technology* **2016**, *12*(3), 137-143. https://doi.org/10.1080/21580103.2015.1135827

[9] Li, S.;Li, J.; Zhang, B.; Li, D.; Li, G.; Li, Y. Effect of different organic fertilizers application on growth and environmental risk of nitrate under a vegetable field. *Scientific Reports* **2017**, *7*, 17020. https://doi.org/10.1038/s41598-017-17219-y

[10] Pant, A. P.; Radovich, T. J. K.; Hue, N. V.; Talcott, S. T.; Krenek, K. A. Vermicompost extracts influence growth, mineral nutrients, phytonutrients and antioxidant activity in pak choi (Brassica rapa cv. Bonsai, Chinensis group) grown under vermicompost and chemical fertiliser. Journal of the Science of Food and Agriculture **2009**, *89*(14), 2383–2392. https://doi.org/10.1002/jsfa.3732

[11] Gonzaga, Z.; Capuno, O.; Labonite, M.; Lonzaga, E.; Napuran, N.; Sarco, A.; Gorme, A.; Rom, J.; Dimabuyu, H.; Jomoc, D.; Estillore, J.; Sentorias, A.; Goldwater,A.; Rogers, G.; McDougall, S. Increasing pechay (Brassica rapa L. ssp. chinensis) production through suitable seedling establishment under two cultivation systems in the Southern Philippines. *Annals of Tropical Research* **2017**, *39* (Supplement B),129-136. https://doi.org/10.32945/atr39sb10.2017

[12] United Nations The 17 goals. Sdgs.un.org. **2015**. Retrieved January 26, 2024, from https://sdgs.un.org/goals

[13] Jimenez, E. F.; Mariano, J. S.; Ferrer, M. J.; De Leon, V. *Pechay Production Guide*. Gov.Ph. (n.d.). Retrieved January 26, 2024, from https://library.buplant.da.gov.ph/images/1641885337Pechay%20Production%20Guide.pdf

[14] Lagon, J.R.; Abad, R.; Bayogan, E.M.; Silvosa-Millado, C.S. Growth and Yield of Screenhouse-grown potted Pechay (Brassica rapa L. ssp. chinensis cv. Black Behi) in selected Davao-produced Composts. *Mindanao Journal of Science and Technology* **2022**, *20*(2), 206-227

[15] Kaur, P.; Bhardwaj, M.; Babbar, I. Effect of vermicompost and vermiwash on growth of vegetables. *Research Journal of Animal, Veterinary and Fishery Sciences* **2015**, *3*(4), 9-12.

[16] Pascual P. R. L.; Jarwar A. D.; Nitural P. S. Fertilizer, fermented activators, and EM utilization in pechay (Brassica pekinensis L.) production. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences* **2013**, *29*(1), 56-69.

[17] Mrabet L.; Belghyti D.; Loukili A.; Attarassi B. Effect of household waste compost on the productivity of maize and lettuce. *Agricultural Science Research Journals* **2012**, *2*(8), 462-469.

[18] Oyege, I.; Balaji Bhaskar, M. S. Effects of vermicompost on soil and plant health and promoting sustainable agriculture. *Soil Systems* **2023**, *7*(4), 101. https://doi.org/10.3390/soilsystems7040101

[19] Khaitov, B.; Yun, H. J.; Lee, Y.; Ruziev, F.; Le, T. H.; Umurzokov, M.; Bo Bo, A.; Cho, K. M.; Park, K. W. Impact of organic manure on growth, nutrient content and yield of Chilli pepper under various temperature environments. *International Journal of Environmental Research and Public Health* **2019**, *16*(17), 3031. https://doi.org/10.3390/ijerph16173031

[20] Codex Alimentarius. Codex General Standard for Contaminants and Toxins in Food and Feed. Fao.org, **2009**. https://rb.gy/m9v04w.

[21] Rashid, A.; Schutte, B. J.; Ulery, A.; Deyholos, M. K.; Sanogo, S.; Lehnhoff, E. A.; Beck, L. Heavy metal contamination in agricultural soil: Environmental pollutants affecting crop health. *Agronomy (Basel, Switzerland)* **2023**, *13*(6), 1521. https://doi.org/10.3390/agronomy13061521

[22] Suleiman, R.; Ibrahim, J. Assessment of Soil Physical and Chemical Properties Under Vegetable Cultivation in Abuja Metropolitan Area, Nigeria. *Zaria Geographer* **2017**, *24*(1), 89-99